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# Statistical and Geographical Analysis of Precipitation and Temperatures of Libya

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**ABSTRACT**

Statistical analysis of the evaluation of climatic parameters is based on available weather data. Analysis was devoted to two climatic parameters – precipitation and temperature time series. Climate data were available from 17 stations in Libya over the 40 years-period (1971 - 2010). Statistical analysis results clearly show a gradual increase of average daily temperatures. The results also show an average reduction amount of the rainfall. The results from geographical analysis are also presented.

*Keywords*—climatic data, climatic stations, GIS, statistical analysis.

## 1. INTRODUCTION

Statistical methods are an important aspect in the environmental sciences as well as in climatology. In the particular case of studying climatic changes and associated problems, it is help for identifying, analyzing and answering scientific questions related to environmental systems.

Description of the climate consisted primarily of estimates of its mean state and estimates of its variability about that state, such as its standard deviations and other simple measures of variability [1]. Several studies have given a great deal of attention to the potential impacts of climatic change and variability in several fields at international level. Statistical analysis for meteorological time series is an important and popular tool for better understanding the effects of climate

variation.

Libya is affected by climate change in many ways, in particular, crop production and food security, water resources, human health, population settlement and biodiversity. Especially drought causes the desertification in the country that accelerates migration from rural and nomadic areas to urban areas as the land cannot support the original inhabitants. Despite the current efforts and ongoing projects being undertaken in Libya in the field of climate change and desertification, urgent actions and projects are needed to mitigate climate change and combat desertification in the near future [2].

Drought is the most complex but least understood of all natural hazards [3]. Libya is facing drought. Statistical analysis for time series can reveal possible trends in time. For drought risk analysis it is very important to study the historical climate parameters (temperature and precipitation) to know if there is a trend, downward or upward or how is their spatial and temporal distribution.

The aim of this paper is statistical and geographical analysis of climatic variables precipitation and temperature, because they have a strong correlation and are related with drought which belongs to main environmental hazards in Libya. Statistical analyses were done using the Microsoft Excel and geographical analyses were done using ArcGIS. ArcView is the simplest module of ArcGIS, software from ESRI Company. It provides tools for creating, processing and organizing geographic and tabular data and metadata. It also provides tools to visualize data in the form of tables, graphs and reports, tools to produce maps and the spatial analysis and other operations related to the creation of maps.

## 2. STUDY AREA

Libya is situated in the north of Africa between Egypt and Algeria, with the Mediterranean in the north and Chad and Niger on its southern borders. Apart from the coastal strip and the mountains in the south, it is desert or semidesert. Libya due to its location between 20 to 34°N experiences a sub-tropical climate. Libya climate is determined by contrasting Mediterranean and Sahara climates, so air masses of either continental or maritime origin affect climate. A costal belt follows the coast receiving more efficient precipitation against the dry, vast area occupied by the Sahara desert. [4], [5].

Climate in Libya is mainly considered the interaction between the Mediterranean Sea and Sahara desert. In general the precipitation extends to cover about 7% of total surface area of the country which is considered about 1.683 million square kilometers. The size varies of the precipitation from year to year and from season to another within the same year.

Climate data were available at 17 stations in Libya over the 40 years - period (1971-2010). Distribution of meteorological stations shows considerable gaps in southern Libya where climatic stations are partially located in major parts of the Sahara. The names and reference numbers of all stations were listed in Table I together with their coordinates and altitude. The distribution of stations is shown in Fig. 1.


**FIGURE 1** DISTRIBUTION OF METEOROLOGICAL STATIONS IN LYBIA

**TABLE I**

LIST OF METEOROLOGICAL STATIONS IN LYBIA

| No. | Station | Latitude (N) | Longitude (E) | Elevation (m) |
|---|---|---|---|---|
| 1 | Nalut | 31.52 | 10.59 | 621 |
| 2 | Garyan | 32.0 | 13 | 796 |
| 3 | Misurata | 32.19 | 15.03 | 32 |
| 4 | Sorman | 32.75 | 12.57 | 18 |
| 5 | Benina | 32.05 | 20.16 | 129 |
| 6 | Derna | 32.47 | 22.35 | 26 |
| 7 | Zuwarah | 32.53 | 12.05 | 3 |
| 8 | Al Jaghbub | 29.45 | 24.32 | -1 |
| 9 | Ghadames | 30.08 | 9.30 | 357 |
| 10 | Sabha | 27.01 | 14.26 | 432 |
| 11 | Ajdabiya | 30.43 | 20.0 | 7 |
| 12 | Homs | 32.63 | 14.3 | 22 |
| 13 | Syrta | 31.12 | 16.35 | 13 |
| 14 | Shahat | 32.49 | 21.51 | 621 |
| 15 | Ghat | 25.13 | 10.13 | 692 |
| 16 | Al Kufrah | 24.13 | 23.18 | 436 |
| 7 | Jalu | 29.02 | 21.34 | 60 |

The meteorological stations in Libya are spatially associated with main human settlements in the northern coastal plain sand the few disperse southern depressions. However, those stations represent the available complete series with acceptable quality data in the country.

All climate information used in this study is represented by original data, according to the official readings from the Libyan Meteorological Department, Climatic Section.

Statistical evaluation was done for selected meteorological variables – precipitation and temperatures in Libya's climatic stations. Stations No. 8, 9, 10, 15, 16 and 17 are continental,

situated in deserted landscape. The others are located in the coastal strip.

## 3. STATISTICAL EVALUATION

Calculation of statistical characteristics include at first course of monthly sum values of precipitation in mm in all stations for period from November 1970 to October 2010 that is presented in Figure 2. In Figure 3 monthly average values of temperature in °C in evaluated period is presented in all stations too. Figures 2 and 3 shows decrease in precipitation data and increase in temperature data during last considered 40 years which means increasing risk of drought in Libya. Statistical analysis of annual precipitation shows the negative trend and positive trend for temperatures, which is confirmed by calculating of values of these trends indicated in Fig. 2 and 3. In case of temperature, the trend is greater (in absolute value).

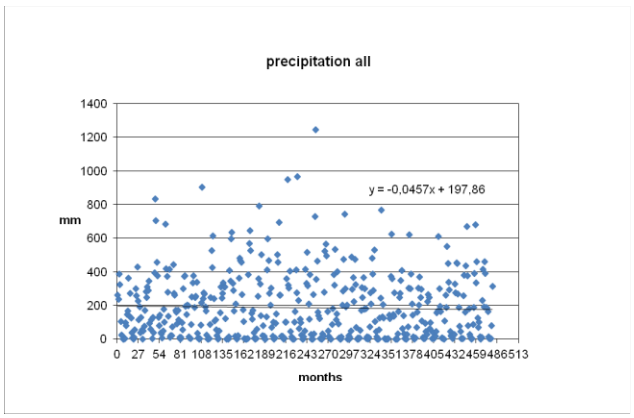


**Figure 2** Precipitation in all stations for all period

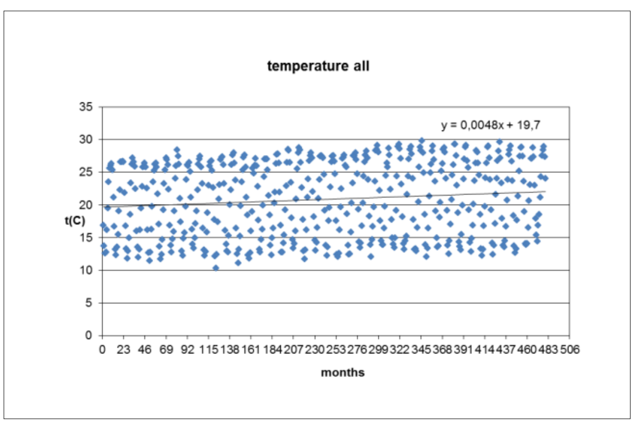


**Figure 3** Temperature in all stations for all period.

Rainfall trends show large variability in magnitude and direction of trend from one station to another. It depends upon many factors, for example latitude, altitude, and distance from the sea.

Figures 4 and 5 show more detailed the progress of precipitation individually for winter (wet), or summer (dry) period respectively, divided separately for stations in the desert compared to stations in the coastal strip. Progress of set of histograms helps us to illustrate the history of the real situation of the precipitation activity during monitored period 1971-2010. Fig. 4 explains also the greater variation of the amount of precipitation shown in Fig. 3, since the stations in the sea belt reported, although not very significant, but still positive rainfall trend in winter period opposite negative trend in summer period.

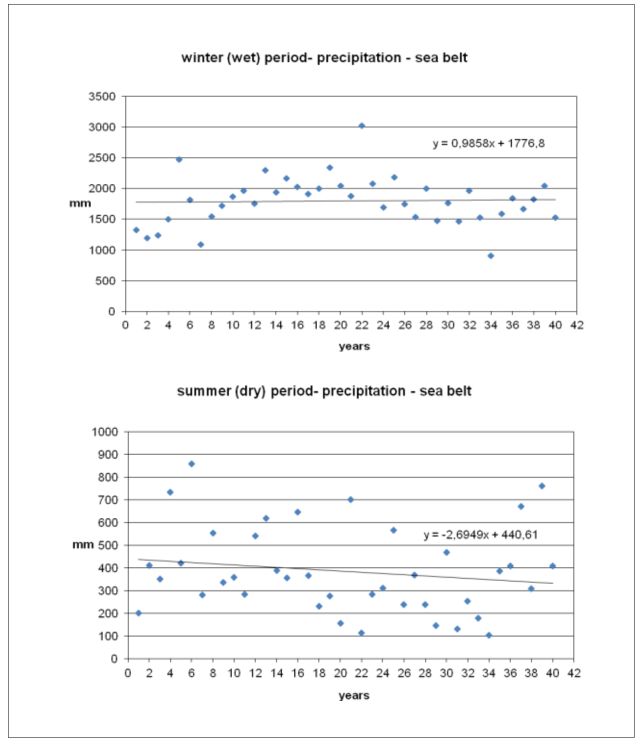


**Figure 4** Precipitation for stations in the sea belt

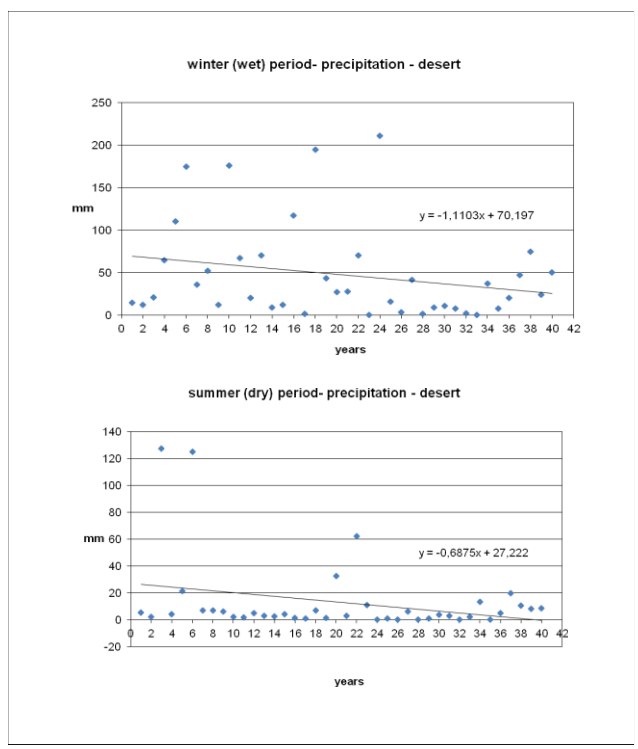


**Figure 5** Precipitation for stations in the desert


**Figure 6** Precipitation for stations in the sea belt

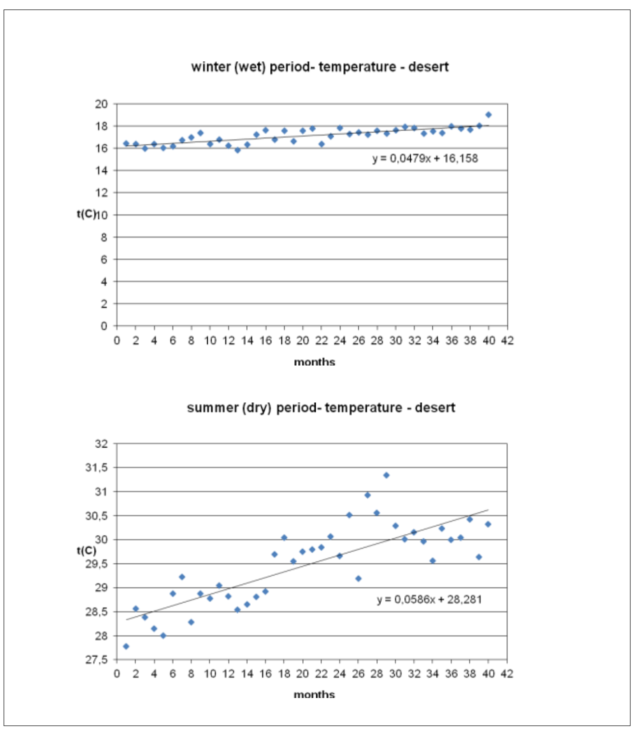


**Figure 7** Precipitation for stations in the desert

Another series of Figures 6 and 7 show detailed history of average temperatures at different times, or zones, respectively. History of these histograms reconfirms the clear trend of slowly increasing average temperatures in all cases. All values of the corresponding trends are of course also positive. If we compare all histograms in Figures 4 -7, it appears, that the "worst" period (it means most dry and hot) was between 1996-2005 and in last years the situation will be "better".

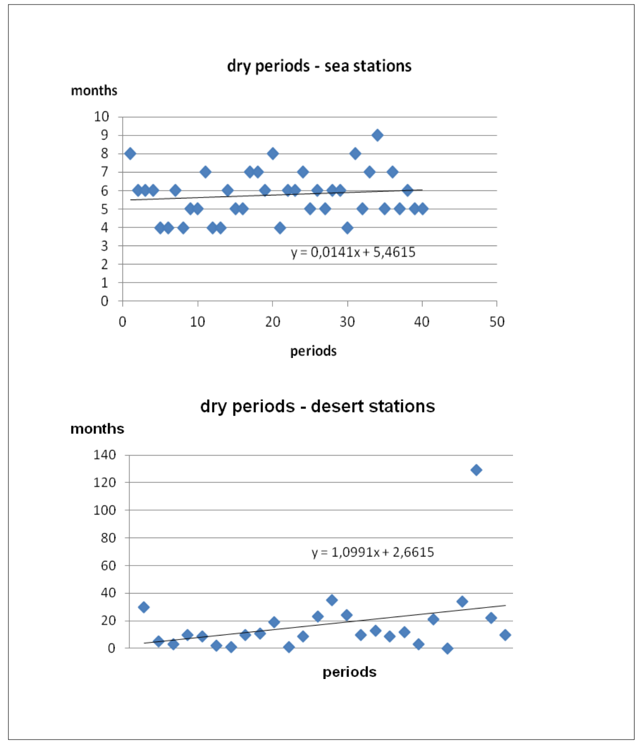


**Figure 8** Dry periods in the sea belt vs. dry periods in the desert.

The last histograms presented in Figure 8 confirms the given reality (it means decreasing trend of precipitation in most stations, which may be not very obvious to any reader from the previous histograms from a different perspective, which represent increasing number of months without precipitation (or precipitation less than 25 mm per month) in desert climatic and decreasing number of rainy months in the rest of stations along the sea, especially between 1996-2005. [2], [6], [7], [8]. We can see a relatively big trend in case of desert stations, due to the one big anomaly, i.e. one especially long period of drought. But if this outlier is omitted, the trend stays still positive.

If we follow the measure of correlation between both, the positive trend of the temperature and the negative trend of the precipitation, is not the same for each considered station. The highest value of the correlation coefficient is 0.57 (moderate correlation) and average value, for all stations, is 0.35 (mild correlation). The higher value is not possible to obtain due to the large variance of the rainfall data.

## 4. GEOGRAPHICAL ANALYSIS

Software ArcView 9.4 (module of ArcGIS from ESRI Company) was used for joining and processing tabular precipitation and temperature data (processed in Microsoft Excel) with geographic localization of climatic stations in Libya. The resulted maps from spatial analyses are presented in figure 9. Analytical aspect of geographical information systems (GIS) was used for creation of the thematic maps of Libya [8]. The tool Inverse Distance Weighting was used for maps creation.

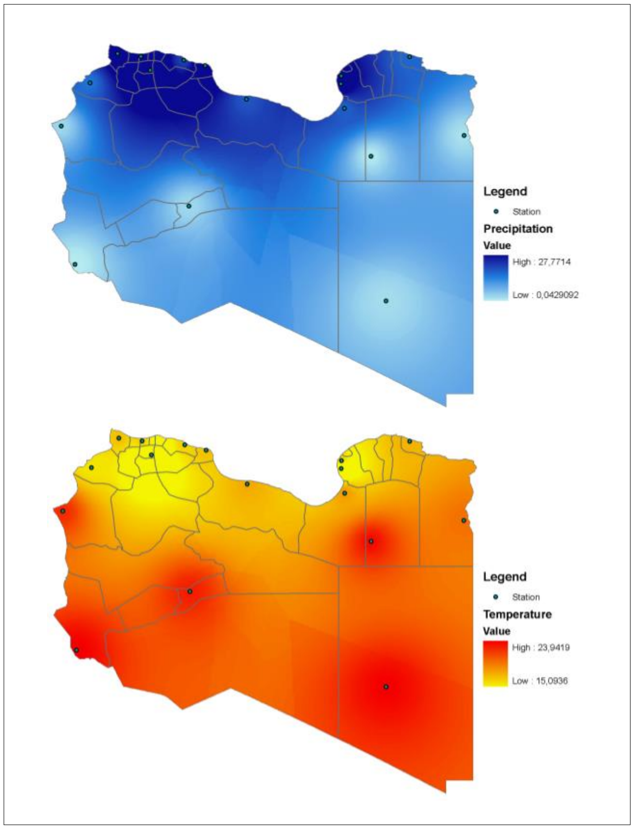


**Figure 9** Spatial distributions of precipitation and temperatures in Libya

## 5. CONCLUSION

From statistical analysis of climatic time series the following can be concluded. The highest risk of drought from above mentioned evaluation is presented in desert part of country, where the significant decreasing trends in precipitation and significant increasing trends in temperatures were indentified. The risk of drought is the most obvious during the summer. Our analysis show, that the both, driest and warmet period was from 1996 to 2005 years. Although in general it is possible to say that the trend in precipitation is decreasing and the trend in temperature is increasing so the risk of drought is increasing in Libya. From geographical analysis results that the most significant impacts of drought are obvious particularly in south, east and west parts of Libya.

In all the Libya regions, water demand is steadily increasing while water supply is steadily decreasing. This is happening with conflicting user pressures from domestic, agriculture, industrial and tourism activities, making how to balance the water equation and to increase water use efficiency a big challenge for water managers and decision makers, particularly under drought conditions.

## ACKNOWLEDGMENT

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